

ARTIFICIAL EYE LENSES

BACKGROUND OF THE INVENTION

This invention concerns improvements in or relating to artificial eye lenses and relates more particularly, but not exclusively, to bi-focal artificial eye lenses. By the term "artificial eye lens" is meant an artificial lens which in use is disposed against the eye or within the eye. Thus one particular type of artificial eye lens is a contact lens which is used against the eye to assist the action of the natural eye lens, and another is an implant lens which is inserted in the eye to replace the natural eye lens.

There have been various prior proposals for contact lenses including bi-focal contact lenses. Generally a bi-focal lens is required to provide a certain power for far vision and a different, usually greater (more positive), power for near vision, the additional power for near vision sometimes being referred to as a "near-add" value which is usually expressed in dioptres. Normally the bi-focal effect is achieved by the use of different curvatures and/or materials of different refractive indices for different parts of the lens, so as to provide the required different powers in the respective different parts, which are often referred to as the far and near zones. Thus the user sees far objects by means of light transmitted through the far zone part of the lens and near objects by means of light transmitted through the near zone part of the lens. It has also been proposed (in U.S. Pat. No. 3,339,997) effectively to utilize the chromatic aberration of the eye and to provide far and near zones which transmit different wavelengths of light. Specifically different parts of the lens providing the far and near zones are made of differently coloured filtering material.

This proposal claims the advantage that the same curvature can be used for the far and near zones, the effective power difference being provided by the different wavelengths transmitted. However, the amount of power difference which can be achieved in this manner is limited. In realistic terms near-add values of up to about one dioptre can be provided by selection of appropriate colours and, although in theory greater values are possible by use of violet for the near zone and red for the far zone, there is the practical problem that the colours are darker and less light enters the eye. Further, such a lens still requires distinct parts providing the near and far zones.

Implant or intra-ocular lenses are designed to be inserted within the eye by an ophthalmological surgeon after the removal of the natural lens for reasons of its pathological conditions such as cataract. Whereas the natural lens may be deformed by the ciliary muscle to effect accommodation, that is the ability of the eye to focus on objects at different distances, the implant lens is both rigid and not connected to the ciliary muscle. The eye thus treated, while giving better vision than previously, is totally lacking in accommodation, a situation that applies to the natural lens in later life due to the hardening of the natural lens, a condition known as presbyopia.

SUMMARY

Broadly according to the present invention there is provided an artificial eye lens having diffractive power, and more particularly an artificial eye lens having a

transmission hologram which provides diffractive power.

The diffractive power, equivalent to lens power, may be over a particular wavelength band or bands so as to have a selective focussing action on light within that wavelength band or bands. Light of other wavelengths can be transmitted through the hologram undeviated by the hologram. The diffractive power may be of less than 100% efficiency such that a proportion of incident light of a relevant wavelength is diffracted while the remainder of the incident light of that wavelength is undeviated by diffraction. The artificial eye lens may have some diffractive power over all or substantially all of the visible spectrum, but there may be different efficiencies, e.g. ranging from about 20% to about 40%, over different parts of the visible spectrum.

An artificial eye lens in accordance with the invention can have a focussing action on that porportion of the incident light it diffracts to which the other incident light is not subject. The lens can thus, for example, have a bi-focal action. The diffractive power may be additive to (or subtractive from) basic refractive power of the artificial eye lens. Thus a bi-focal artificial eye lens in accordance with the invention may have a basic power, e.g. for far vision, provided by the shape, curvature and material of the lens, and a different power, e.g. a greater power for near vision, through the diffractive power provided in particular by a transmission hologram. The hologram may be provided over the full area, or the full visually used area, of the artificial eye lens and thus, with a bi-focal lens, can avoid need for distinct near and far vision zones.

In principle the difference in power provided by the diffractive power, which would usually be additive to the basic power, can be any desired number of dioptres. In practice the power of the transmission hologram is preferably up to about four dioptres so that a bi-focal artificial eye lens in accordance with the invention may for example have a near-add value between 0 and +4 dioptres.

The hologram may be formed in a layer of the artificial eye lens. Alternatively the hologram may be formed actually in, or as a surface variation on, the bulk material of the artificial eye lens.

In the case of a contact lens the hologram may be formed in a surface layer of photographic material, such as dichromated gelatin, such layer normally being on the surface of the lens which in use is remote from the eye. Alternatively the hologram may be formed actually in the bulk material of the contact lens. In general hologram formation in a surface layer is more appropriate with a hard contact lens while hologram formation in the bulk material is appropriate with a soft contact lens or a hard contact lens.

In the case of an implant lens the hologram may be formed actually in the bulk material of the lens, or may be formed in a layer of photographic material, such as dichromated gelatine, such layer normally being located within the implant lens, e.g. sandwiched between parts thereof.

The hologram may be optically generated by use of active and reference light beams, e.g. from a laser, directed at the artificial eye lens from locations, e.g. effectively providing point sources, appropriate to the power required in the resultant hologram. Such beams produce interference fringes, the vergence difference between the active and reference beams being equal to the required power in the resultant hologram. In practice